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NASA
GODDARD SPACE FLIGHT CENTER

STATEMENT OF WORK

FOR

TECHNOLOGY AND INTEGRATED DISCIPLINE ENGINEERING
SERVICES (TIDES)

FOR THE

APPLIED ENGINEERING AND
TECHNOLOGY DIRECTORATE (AETD)

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INTRODUCTION

The National Aeronautics and Space Administration (NASA) was established to plan, direct, and conduct aeronautical and space activities for peaceful purposes for the benefit of all mankind. The operational aspects of NASA's work are divided among field installations around the country and involve research and development activities under the responsibility of four technical program offices at NASA Headquarters.

The Goddard Space Flight Center (GSFC) has primary locations in Greenbelt, Maryland and Wallops Island, Virginia. The GSFC is chartered to expand the knowledge of the earth and its environment, the solar system, and the universe through observations from space. To this end, the GSFC's primary emphasis is in scientific investigation, in the development and operation of space systems, and in the advancement of essential technologies. In accomplishing this responsibility, the GSFC has undertaken a broad program of scientific research, both theoretical and experimental, in the study of space phenomena and earth sciences. The program ranges from basic research to flight experiment development and from mission operations to data analysis.

Within the GSFC, the Applied Engineering Technology Directorate (AETD) plans, organizes, and conducts a broad range of technical research and development activities in support of science applications. The AETD is responsible for providing engineering expertise and support in the formulation, design, development, fabrication, integration, test, verification, and operation of components, subsystems, systems, science instruments, and complete spacecraft for multiple projects. The specific components, subsystems, systems, and science instruments are ultimately integrated into the spacecraft to form a science observatory. It is these observatories that are launched to fulfill the mission of the GSFC. The AETD comprises five engineering divisions: the Mechanical Systems Division (MSD), the Software Engineering Division (SED), the Instrument Systems and Technology Division (ISTD), the Electrical Engineering Division (EED), and the Mission Engineering and Systems Analysis Division (MESAD).

To fulfill these responsibilities and ultimately achieve their missions, the AETD must acquire a wide range of engineering services in support of its divisions to implement the GSFC mission.

SCOPE OF WORK

The purpose of this contract is to acquire engineering and related services to MESAD and related organizations, as required, for the formulation, design, development, fabrication, integration, testing, verification, and operations of guidance, navigation and control (GN&C) space flight and ground system hardware and software, including development and validation of new technologies to enable future space and science missions. The emphasis in engineering services will be in the area of guidance, navigation, and control systems, which includes GN&C systems engineering, Attitude Control Systems (ACS) hardware and software development, and propulsion engineering and development.

To this end, the contractor shall provide on/off-site multidisciplinary engineering services, pursuant to Task Orders issued by the Contracting Officer. These services shall include the personnel, facilities, and materials (unless otherwise provided by the Government) to accomplish the tasks.

Task Orders will be issued to perform services in all aspects of mission and instrument development and implementation for components, subsystems, systems, science instruments, observatories, launch, ground system, spacecraft, and suborbital craft (e.g., aircraft, sounding rockets, unmanned aerial vehicles (UAVs), balloons), including services for the following: free-flying spacecraft, suborbital craft payloads, and Space Station payloads as well as ground support equipment, simulators, non-flight models, prototypes and flight hardware; candidate, feasibility, and systems definition studies; project management; systems engineering; analysis; preliminary design; detailed design; fabrication; assembly; integration; test and verification; test instrumentation; data systems management; launch and post-launch operations; research and technology unique to system development; documentation; maintenance; sustaining engineering; configuration management; mission assurance; architectural trades; performance, cost, and risk assessment; and systems safety.

I. GENERAL RESPONSIBILITIES

The Contractor's responsibilities shall include the establishment of a management organization for the management of personnel; timely and effective implementation of Task Orders; control and monitoring of contract and subcontract performance; management of scheduled deliveries; and timely and effective reporting to the Government. These responsibilities shall also include efficient cost management methods as well as procedures to ensure that the Government is aware of Task Order status and progress achieved during all phases of work.

The Contractor shall be responsible for ensuring that all contractor and subcontractor personnel engaged in performance of this Statement of Work have appropriate qualifications, knowledge, and certification to perform work in accordance with the Task Orders.

II. PERFORMANCE MEASUREMENT

Performance-based statements of work/specifications will be used for establishing contract requirements. Therefore, each Task Order issued by the Contracting Officer will include, as a minimum, the following:

1. Statement of Work, including the requirements to be met, the standard(s) of performance/quality of work, and required deliverables (or other output)
2. Performance Specification (if applicable)
3. Applicable Documents (if required)
4. Period of Performance

The Contractor shall be required to adhere to the performance measurements detailed in each Task Order.

III. TASK ORDERS

Services shall be required in one or more of the areas described in the scope above for any given Task Order. Services within the scope of this Statement of Work and specified in Task Orders shall include, but not be limited to, the specific services delineated in the following sections.

FUNCTION 1 – DISCIPLINE ENGINEERING SUPPORT FOR PRE-FORMULATION AND FORMULATION SERVICES: CANDIDATE AND PRELIMINARY ANALYSIS STUDIES

The Contractor shall provide discipline engineering services as required for mission concept development that integrate the aspects of flight systems, ground systems, instrument systems, and launch systems.

In general, the Contractor shall:

1. Support pre-formulation and formulation phase study inputs for spacecraft, suborbital craft, and instruments.
2. Develop preliminary, relative cost and schedule estimates based on design alternatives, and identify and assess high-risk elements in designs.
3. Document the history of design, qualification, flight experience, and modifications where existing components or subsystems are to be utilized.
4. Provide subsystem requirements for pre-launch, launch, on-orbit servicing, or retrieval of flight hardware.
5. Prepare requirements and specification packages that conform to applicable standards defined within Task Order statement.
6. Prepare interface control documents.
7. Provide technical inputs for problem-solving and/or design inputs in selected spacecraft, instruments, suborbital craft, ground system, and data disciplines.
8. Analyze various reports (e.g., progress reports) delivered by the GSFC mission contractor(s) and provide recommendations to the project.
9. Provide liaison and coordination services between the subsystem and project teams.
10. Provide design services that include performance of preliminary design (leading to a Preliminary Design Review) of the subsystems, components, and assemblies that comprise the instrument/spacecraft/platform/launch system.

A. Candidate Study Services

The Contractor shall provide study services for the conceptual design and development of subsystems, thereby participating in the identification of scientific objectives, mission requirements and technical concepts.

B. Preliminary Analysis Study Services

The Contractor shall provide preliminary analysis study services focusing on analyzing subsystem requirements in order to demonstrate that a credible, feasible design(s) exist(s). Study products produced during this phase shall include:

Analysis Services Specific Task Orders – The Contractor shall perform analysis services Task Orders, including but not limited to:

1. Preliminary design of a feasible, but not necessarily optimum configuration.
2. Assessment of technical risks, including identification of technical problems and the criticality of their solution to follow-on efforts; identification of those problems currently

being addressed, and a judgment of effort and time likely to be necessary to find a practical solution .

3. Identification of all recommended subsystem characteristics.
4. Supporting the development of the System Implementation Plans.
5. Preparation of the subsystem design that forms the basis for implementing system development (hardware or software).
6. Providing alternative subsystem design concepts including feasibility and risk studies, cost and schedule estimates, and advanced technology requirements.
7. Preparing for and supporting the appropriate Phase A project and technical reviews and prepare Phase A project documentation as appropriate (see the NASA Systems Engineering Handbook, SP-6105, December 2007).

FUNCTION 2 – IMPLEMENTATION PHASE SERVICES - DISCIPLINE SPECIFIC SERVICES

A. Guidance, Navigation and Control (GN&C) Engineering Services

The Contractor shall provide GN&C engineering support for all phases of project development, monitoring and reporting progress and conformance to appropriate practices and specifications. This shall include:

1. **GN&C Systems Engineering Specific Task Orders** – The Contractor shall perform specific GN&C systems engineering tasks that include:
 - a. Flight Project GN&C Subsystem Engineering, including requirements development; analysis; trade studies; ICD development; verification and validation; risk management; general coordination of all GN&C elements; maintenance of mass, power, and pointing budgets; operations planning
 - b. GN&C Conceptual Design, Modeling and Simulation
 - c. GN&C Science and Instrument Interface Engineering
 - d. Spacecraft Re-entry Systems Engineering
 - e. Re-entry Debris Analysis, Modeling and Simulation
 - f. GN&C Engineering Support to Integrated Mission Design Lab (IMDL)
 - g. Advanced GN&C Systems Technology Development, including the design, analysis, fabrication, assembly, and test of hardware and/or software
 - h. Advanced GN&C Testbeds, Tools and Methods Development
 - i. Balloon, UAV and Sounding Rocket GN&C Engineering
 - j. Formation Flying Test Bed (FFTB) Design and Development
 - k. Rendezvous Proximity Operations, Docking, Undocking (RPODU) Systems
 - l. Autonomous Rendezvous & Capture (AR&C) Systems
 - m. Pose Estimation Systems
 - n. Technical Consultation and Support (Proposals, Peer, Design, and Anomaly Reviews)
2. **GN&C Analysis & Simulation Specific Task Orders** – The Contractor may be called upon to perform specific GN&C analysis and simulation engineering tasks that include:
 - a. Attitude Design, Analysis and Simulation
 - b. Attitude Control Design, Analysis and Simulation
 - c. Space and Launch Vehicle Dynamics Analysis and Simulation
 - d. Control/Structure Interaction Analysis and Simulation
 - e. Attitude Estimation Design, Analysis and Simulation
 - f. Aerodynamics Design, Analysis and Simulation
 - g. Formation Flying/Constellation Design, Analysis and Simulation
3. **Component and Hardware Systems Engineering Specific Task Orders** – The Contractor shall perform specific GN&C component and hardware systems engineering tasks that include:

- a. Advanced GN&C Sensor/Actuator Design, Development, Fabrication and Test (hardware and/or software).
 - b. Design, Development, Fabrication and Test (hardware and/or software) of sensor/actuator interfacing electronic components and subsystems.
 - c. Analog and digital circuit design and analysis
 - d. Printed circuit board layout, fabrication and assembly.
 - e. Electronics packaging, including design, analyses, fabrication, assembly, testing and verification.
 - f. Field Programmable Grid Array (FPGA) development and testing
 - g. Electrical Technician tasks for the fabrication, assembly, integration and test of printed circuit boards, including certified soldering, crimping, staking, harness fabrication, electrical component test and integration.
4. **Propulsion Engineering Specific Task Orders** – The Contractor shall perform specific spacecraft propulsion systems engineering tasks that include:
- a. Spacecraft Propulsion Subsystem Engineering, including concept design, design maturation, requirements definition and verification, integration and testing, propellant handling, launch support, and flight operations support.
 - b. Advanced Propulsion Technology Development, including advanced chemical propulsion, green propulsion, electrical propulsion (EP), Micro-Electrical-Mechanical Systems (MEMS), micro-propulsion components; test equipment and instrumentation to support development & testing of sub-microN thrusters.
 - c. Fluid Systems Engineering including transient flow, vapor diffusion, fluid slosh and plume impingement analyses.
 - d. Power & Electric Propulsion System Engineering, including low thrust trajectory design; EP system design & trades; EMI testing, analysis and mitigation.
 - e. Nanocalorimetry
 - f. Propulsion Chemical Analyses
 - g. Propulsion GSE Design and Development
 - h. Propulsion System Engineering Support to IMDL and advanced mission studies
 - i. Propulsion System Engineering Support to Flight Project, including technical consultations and engineering support for design reviews, analyses, proposal development, and anomaly resolution. Data Acquisition Engineer, including software and hardware design, development and test.
 - j. Mechanical and Thermal Engineering Support specific to propulsion system design and analysis.
5. **Propulsion System Technician Specific Task Orders** - The Contractor shall perform specific spacecraft propulsion system technician tasks that include:
- a. Mechanical Technician tasks for the fabrication, assembly, integration and test of propulsion subsystems, including subsystem manifold fabrication, precision cleaning, certified welding, integration of propulsion subsystem components, propellant handling and clean room operation.

- b. Electrical Technician tasks for the fabrication, assembly, integration and test of propulsion subsystems, including certified soldering, crimping, staking, harness fabrication, electrical component test and integration.
- c. Advanced Propulsion Technology Development Technician tasks, including conducting micro-Newton thrust stand tests; vacuum system assembly, maintenance and operation; chemical handling; fluid system assembly and operation.

B. GN&C Related Engineering Services

The Contractor shall provide GN&C engineering support for all phases of project development, monitoring and reporting progress and conformance to appropriate practices and specifications. This shall include:

1. Test Bed & Simulator Design/ Development Services

The Contractor shall provide engineering services for the design, development, validation, implementation, certification and maintenance of ground or on-board computer system simulators/emulators, including validation of flight system software for ascent, transfer, or on-orbit phases and near real-time reprogramming and validation of modifications for recovery from anomalous situations.

2. Radio Frequency (RF) Engineering

The contractor shall provide design, analysis, fabrication and testing services for RF systems and components including but not limited to oscillators, transmitters, receivers, low noise amplifiers, filters, synthesizers and mixers. The contractor should also have knowledge of and experience with transmission lines and antennas.

Task Orders may include, but not be limited to the following:

- a. RF system design including receiver architecture
- b. RF and microwave RF circuit design, analysis and testing
- c. RF system testing utilizing the Formation Flying Test Bed (FFTB)
- d. EMI/EMC environmental test support

3. Optical Engineering Services

The Contractor shall provide, on an as-needed basis, engineering services for state-of-the-art optical systems. These services shall include, for example, the design, development and analysis of optical components, diffraction and stray light/energy analyses, component/system alignment and/or calibration, and/or other services, as required.

4. Detector Engineering Services

The Contractor shall provide, on an as-needed basis, engineering services for state-of-the-art X-Ray, Gamma Ray, Visible, RF, and Microwave detection systems requiring low noise levels and calibrations traceable to physical standards. These services shall include, for example, Field Programmable Gate Arrays design and analyses, and/or other services, as required.

5. Laser Engineering Services

The Contractor shall provide, on an as-needed basis, engineering services for state-of-the-art Laser systems. These services shall include, for example, the design, development and analysis of laser transmitters, laser transmitter components, laser-based GN&C components, laser-based communication systems, laser-based science instruments, laser-based science instrument subsystems and components.

C. Systems Engineering Services

The Contractor shall provide systems engineering support for project development, reporting progress and conformance to appropriate practices and specifications (see the GPR 7123.1 Systems Engineering). These services shall include but not be limited to: operations concept development and support; architecture and design development; requirements analysis, identification and management; validation and verification; interfaces and interface control documents (ICDs); mission environment requirements; technical resource budget tracking; risks analysis, reduction and management; systems milestones review candidates; configuration management and documentation; and systems engineering management plan.

The Contractor shall provide instrument systems engineering support for project development, reporting progress and conformance to appropriate practices and specifications (see the GPR 7123.1 Systems Engineering). These services shall include but not be limited to: instrument data processing development and support; instrument architecture and design development; requirements analysis, identification and management; validation and verification; interfaces and interface control documents (ICDs); instrument environment requirements; technical resource budget tracking; risks analysis, reduction and management; instrument systems milestones review candidates; configuration management and documentation; and instrument systems engineering management plan.

FUNCTION 3 – IMPLEMENTATION PHASE SERVICES - MULTI-DISCIPLINARY FUNCTIONS

The Contractor shall provide services to design, develop, test, integrate, verify, deploy, and operate hardware and software on spacecraft, platform, and/or payload as defined by this Statement of Work. The implementation phase services shall include:

A. Multi-disciplinary Analyses Services

The Contractor shall provide analytical and detailed design support that includes multi-disciplinary subsystem analyses and trade studies involving, but not limited to, mechanical, thermal, optics (including radiometrics and stray light), contamination, control, guidance, navigation, detector, electrical, electronic, and software aspects of flight and ground systems, including associated ground support equipment. Services shall include the definition, development and use of models and simulations to study and quantify system performance and to conduct system trade studies. This includes, but is not limited to, such specific efforts as electromagnetic interference/electromagnetic contamination (EMI/EMC) analysis, environmental testing, magnetics testing, thermal vacuum testing, systems performance error budgets, power and weight budgeting and tracking, microphonics analyses, fracture control analyses, microwave communication system analyses (including link margin availability), controls-structures analyses, control-structural-thermal-optical analyses, instrument system analyses (including system sensitivities), computer performance analyses (including CPU, memory, simulations, etc), and reviews of selected critical subsystems. Services shall also include the development of measurement tools and models, analysis of measurement data, defect tracking, process improvement, cost estimation of hardware and software systems, modeling of organizational processes, electrical parts analyses, electrical board layouts, thermal analysis, electrical board fabrication, mechanical enclosure design, and technical writing documentation.

The Contractor shall document all results from the modeling, simulations, analyses, and design effort and shall provide supporting materials and documentation.

B. Multi-disciplinary Design Services

The Contractor shall provide design services that include performance of detailed (leading to a Critical Design Review) design of the subsystems, components and assemblies that comprise the instrument/spacecraft/platform. This effort includes hardware and software (flight and ground) as well as ground support equipment (electrical, thermal, contamination, mechanical, and cryogenic). Documentation, including technical reports, drawings, schematics, block diagrams, layouts, parts and materials list, and equipment lists, shall be provided.

The Contractor shall document all results from the modeling, simulations, analyses, and design effort and shall provide supporting materials and documentation.

C. Fabrication, Assembly and Testing Services

The Contractor shall provide fabrication, assembly and testing services, including breadboards, engineering models, and other models, including:

1. **Planning Specific Task Orders** – The Contractor shall provide planning services, including:
 - a. Implementation and maintenance of overall production and quality engineering plans
 - b. Manufacturing, integration and test plans, describing sequences, qualification and acceptance test levels, and facilities needed to accomplish assembly, integration, alignment, testing, quality control, and checkout.
2. **Non-Flight & Flight Fabrication Specific Task Orders** – The Contractor shall provide or support fabrication services, including:
 - a. Optical, mechanical, detector, electrical/electronics, and microwave components and subsystems, including antennas. Mechanical systems shall include pressurized propulsion systems containing hazardous fluids.
 - b. Ground support equipment, including mechanical, electrical, and optical components and subsystems.
 - c. Wiring harnesses
 - d. Special parts
 - e. Surface mount printed circuit boards, including leadless chip carriers and chip-on-board techniques.
3. **Non-Flight & Flight Assembly Specific Task Orders** – The Contractor shall provide assembly services, including:
 - a. Optical, mechanical, detector, electrical/electronics, and microwave components and subsystems, including antennas. Mechanical systems shall include pressurized propulsion systems containing hazardous fluids.
 - b. Ground support equipment including mechanical, electrical, and optical components and subsystems.
 - c. Test equipment and fixtures
 - d. Wiring harnesses
 - e. Surface mount printed circuit boards, including leadless chip carriers and chip-on-board techniques.

D. Integration, Test, and Verification Services

The Contractor shall provide engineering and test-conductor services that include integrating and verifying the flight, ground systems, and science data system; preparing and executing test procedures; documenting all non-conformances and dispositions; providing operating manuals, reference documents, training, and launch site support.

Integration, Test and Verification Specific Task Orders – The Contractor shall provide integration, test, and verification services including acceptance testing, regression testing, software support and subsystem-level support of products during component, box, instrument, spacecraft and observatory I&T including:

1. Major program reviews
2. Space flight subsystems
3. Space flight instruments
4. Space flight payloads
5. Suborbital craft instruments
6. Ground instrumentation
7. Ground support systems
8. Science data systems/applications
9. Spacecraft and science operations control rooms
10. Suborbital craft subsystems

E. Laboratory and Test Instrumentation Services

The Contractor shall provide the services necessary for conceptualization, prototyping, design, development, integration, test, sustaining engineering, maintenance and utilization of laboratory and test instrumentation.

F. Launch and Post-Launch Operations Support

The Contractor shall supply launch and post-launch mission, hardware, software, and ground systems support services for Expendable Launch Vehicles (ELV), sounding rocket, balloon, and aircraft-based missions, including:

1. **Launch Site Preparation Specific Task Orders** – The Contractor shall provide support services at the launch site, including:
 - a. Support to payload system and its support equipment
 - b. Interfaces to the mission operations control centers
 - c. Technical services to facilitate interfacing with the launch site organization
 - d. Development of launch site support requirements
 - e. Development of launch site plans and procedures
 - f. Support for shipment of the flight hardware and associated support equipment to and from the launch site.
2. **Launch Operations Specific Task Orders** – The Contractor shall provide launch and post-launch operations services for ELV, sounding rocket, balloon, and aircraft-based missions, including:
 - a. Assuring flight readiness of the payload and observatory system
 - b. Pre-launch testing of the payload and observatory system
 - c. Operation of associated ground support equipment
 - d. Services to the launch vehicle team for payload integration to the vehicle at the launch facility.

3. **Mission Operation Support Specific Task Orders** – The Contractor shall provide mission operation engineering services, including services for the payload and for carrier and flight support system during launch and early orbit mission operations.
4. **Landing and De-Integration Specific Task Orders** – The Contractor shall provide landing and de-integration services, including services at the landing site for payload de-integration, post-flight testing, and payload shipment. This shall include suborbital craft and payloads recovery.
5. **Refurbishment of Recovered Systems Specific Task Orders** – The Contractor shall provide refurbishment services for recovered flight systems.
6. **Data Reduction Specific Task Orders** – The Contractor shall provide data reduction services, including:
 - a. Compiling and analyzing subsystem performance data during and after the mission
 - b. Reviewing and contributing to the implementation of proposed science data processing systems to ensure timely flow of accurate science data sets
 - c. Reviewing the design and implementation of information data systems to identify sources of science data for investigative purposes, including existing databases and newly acquired data requirements to be scheduled
 - d. Analyzing the development of data transfer systems and data status accounting systems for multiple science data processing centers
7. **Documentation Specific Task Orders** – The Contractor shall provide post-flight summary reports, analyzing the performance of the subsystem during flight.

G. Mission Assurance and Systems Safety Services

For all levels of flight hardware and software provided by the Contractor and specified by this Statement of Work, the Contractor shall establish and maintain a mission assurance program commensurate with mission requirements as specified by the Task Order. The mission assurance program shall incorporate a system safety program which meets the requirements of National Space Transportation Systems (NSTS) 1700.7B, “Safety Policy and Requirements for Payloads Using the Space Transportation System”. For ELV missions at ETR or WTR, the system safety program shall meet the requirements of AFSPCMAN 91-710, Range Safety User Requirements Manual.

The contractor shall establish and maintain practices, procedures, and processes that are ISO Q9001-2000 compliant.

1. **Performance Assurance Specific Task Orders** – The Contractor shall provide performance assurance services, including:
 - a. Reviewing payload designs to assure their compliance with performance assurance, reliability, and safety specifications.
 - b. Developing, analyzing, and monitoring performance assurance, reliability,

- system safety plans and procedures, fabrication and assembly, integration and test, verification, and launch support.
- c. Analyzing basic plans for system safety, contamination control, integration, and testing of subsystems and systems
2. **Safety Specific Task Orders** – The Contractor shall provide safety services which conform to the system safety/mission assurance program, including:
- a. Establishing and documenting a systems safety plan in concert with the appropriate launch vehicle and NASA safety policy.
 - b. Conducting and assessing system safety analyses for flight designs and launch/retrieval operations to satisfy NASA safety and reliability requirements.
 - c. Analyzing design changes related to minimizing hazard levels.
 - d. Participating in system safety reviews.
 - e. Reviewing the proposed systems design to ensure that proper considerations are given to safety-critical areas, and that safety problems exposed in prior analyses, testing, and operational use of instruments and subsystems are corrected.
 - f. Conducting project test/validation programs for flight and critical ground systems software.
 - g. Preparing the Safety Data Package, including writing and editing.
 - h. Performing hazards analysis of flight system and ground support equipment.
 - i. Participating in required inspection/testing to fulfill safety data requirements.
 - j. Coordinating with the GSFC safety officer and participating in formal safety reviews.

FUNCTION 4 – RESEARCH AND TECHNOLOGY SERVICES

The contractor shall provide advanced research and technology support to MESAD and related organizations. These services may include development, test, and analysis work in support of the Research and Technology activities.

A. GN&C Systems Technology Services

The Contractor shall provide research, design, development, analysis, and testing services for GN&C systems, including but not limited to:

1. **GN&C Systems Specific Task Orders** – The Contractor shall provide services for the research and development of advanced analytical, engineering, integration, testing, and software engineering techniques including, but not limited to:
 - a. GN&C Systems Performance modeling
 - b. GN&C Systems signal to noise analysis
 - c. Rendezvous Proximity Operations, Docking, Undocking (RPODU) Systems
 - d. Autonomous Rendezvous & Capture (AR&C) Systems
 - e. Pose Estimation Systems
 - f. Advanced Global Positioning System algorithms
 - g. Miniaturization and Micro-Electromechanical (MEMS) Devices
 - h. Advanced Propulsion Systems, including advanced chemical propulsion, green propulsion, electrical propulsion (EP), Micro-Electrical-Mechanical Systems (MEMS), and micro-propulsion components

B. GN&C Electronics Systems Technology Services

The Contractor shall provide services for research, design, development, test, and analysis of advanced signal processing electronics for space flight systems, including support for language-based microelectronics development. The Contractor shall provide services for sensor signal processing technology Task Orders, digital signal processing technology Task Orders, and advanced applications technology Task Orders.

C. Software Systems Technology Services

The Contractor shall provide technology services for the research and development of advanced software topics, including:

1. Automation and artificial intelligence applications
2. Software engineering
3. Distributed processing
4. Embedded software systems
5. Visualization and virtual environments
6. Data processing, archival and distribution
7. Simulation and modeling
8. Middleware

D. Systems Technology Services

The Contractor shall provide services for the research and development of advanced technologies for end-to-end mission architectures, systems, subsystems, components, devices, and elements for spacecraft, balloons, UAV's, sounding rockets, instruments, and other platforms, including:

1. Technology validation
2. Technology infusion
3. Technology state-of-the-art and gap analyses
4. Strategic technology planning and road mapping
5. Technology study/proposal support
6. Technology infrastructure/facility requirements planning
7. Technology special studies, including the development and refinement of technology enabled missions
8. Technology tracking, documentation and reporting
9. Technology prototyping

FUNCTION 5 – SUPPORT SERVICES

The Contractor shall provide support services covering all items within the scope of this SOW, as specified in task assignments. All work shall be performed in accordance with the latest versions of the applicable documents, specifications and standards under this SOW, and as further specified on individual task orders.

A. Computer Support Technology Services

The Contractor shall provide computer technology services, including:

1. **Computer Support Specific Task Orders** – The Contractor shall provide computer technology services, including:
 - a. Engineering support to analyze data acquisition, processing, distribution, archival/storage, and measurement problems
 - b. Data reduction to include statistical and thematic trends analyses
 - c. Diagnostics support for instrument checkout between test consoles and test components
 - d. Program services to utilize test instruments in aerospace system test and analysis, including General Purpose Interface Bus (GPIB) type operation and Graphical User Interface (GUI) based software system
 - e. General in-house computer software maintenance to include, but not be limited to, updating and debugging programs
 - f. Design, coding, integration, test, documentation, and maintenance of special applications programs
 - g. Updating of existing technical in-house computer databases
 - h. Transfer of programs from one system to another and testing for functional operations and real time data transfer between dissimilar systems
 - i. Debugging of general utility programs, such as graphic packages
 - j. Support in analyzing and implementing solutions to computer hardware interface problems
 - k. Support for network and operating system configurations, troubleshooting, installation, and maintenance
 - l. Design and debug of test procedures
2. **Web Page Development and Maintenance Function** – The contractor shall provide web development services to help promote organizational capabilities, including:
 - a. Development, maintenance, and upgrade of web sites
 - b. Management of mission test facilities that require significant computer capabilities
 - c. Compliance to Agency and Center policy (GSFC Webmaster) such as 508 compliance and Post 9-11 accessibility compatibility
 - d. Defining with customer the look and feel of the web site, and reviewing web site requirements
 - e. Developing prototype web sites for maturing web based concepts
 - f. Providing maintenance services to keep web site up to date and compliant

B. Configuration Management Services

The Contractor shall provide overall management and oversight of the Configuration Management (CM), Documentation Management (DM), and Quality Control Management (QCM) disciplines throughout the life cycle of flight hardware and software provided within the scope of this Statement of Work. Each discipline shall require the development, establishment, and implementation of procedures and processes and establishment of mechanisms and tools for consistency.

The Contractor shall support the planning, identification of processes, and leading GSFC Project efforts in these disciplines. This support shall also include the necessary planning and associated process development for the GSFC Project in meeting conformance requirements to NASA procedures and guidelines as well as the ISO standards.

The main CM/DM/QCM functions shall include:

- Configuration identification, configuration control, configuration accounting and reporting
- Configuration verification and configuration auditing
- Implementation and maintenance of a DM system

The Contractor shall be responsible for providing the necessary tools and databases to accomplish the above functions; developing and establishing procedures and guidelines and training in the configuration management, documentation management, and ISO Q9001-2000 disciplines.

C. Documentation Services

The Contractor shall provide documentation services for all levels of hardware and software within the scope of this Statement of Work, as specified in Task Orders. Documents shall conform to applicable documents and specifications. These shall include pertinent performance assurance guidelines, quality standards, GSFC standards, documents of other NASA Centers, Federal standards, military standards, and commercial standards.

The Contractor shall provide documentation services, including instrument conceptual designs, program plans, systems analyses, illustrations, technical and implementation plans, test plans, test procedures, test scripts, software documentation, and the full range of system hardware and software documentation. These shall also include up-to-date drawings, specifications, certifications, reports, interface control documents, and agreements.

1. **Document Services Specific Task Orders** – The Contractor shall provide electronic media and document services, including:
 - a. Technical writing
 - b. Editing
 - c. Drafting
 - d. Computer-Aided Design (CAD)/Computer-Aided Manufacturing (CAM)
 - e. Photographic

- f. Video
- g. Reproduction
- h. Compact Disc (CD), Digital Versatile Disc (DVD)
- i. Posters and Displays

2. **Photo and Video Specific Task Orders** – The Contractor shall use photos and video for maintenance, engineering, or as documentation to explain a problem. They shall become supplemental to support unit repair or future development and maintenance. A scale shall be included to indicate relative dimensions in photographs and/or video, where appropriate.

D. Demonstration, Presentation and Conference Services

The Contractor shall provide technology services for hardware and software demonstrations, technical/project/conference presentations, and conference planning/implementation for items within the scope of this Statement of Work, including:

1. **Demonstration Specific Task Orders** – The Contractor shall provide hardware, software, support equipment, and technical services for onsite and offsite demonstrations.
2. **Presentation Specific Task Orders** – The Contractor shall provide materials for inclusion in technical/project/conference presentations, including posters, information, photographs, etc. In addition, the Contractor shall perform the presentation.
3. **Conference Specific Task Orders** – The Contractor shall support the Government by providing services in the planning and implementation of conferences.

E. Laboratory & Office Safety/Property Program Services

The Contractor shall provide services to support laboratory/office safety and property programs including:

1. Performing safety audits and walkthroughs.
2. Documenting safety hazards and recommending corrective actions.
3. Performing property audits and documenting results.
4. Creating training materials to ensure employees are cognizant of all relevant safety policies and procedures.

F. Maintenance Services

The Contractor shall provide maintenance support to ensure long term reliability through an integrated and efficient approach, including:

1. **Preventative Maintenance**

The Contractor shall perform preventative maintenance on hardware and software within the scope of this Statement of Work as specified in Task Orders.

2. Emergency Repair Services

The Contractor shall provide expeditious emergency repair services for hardware and software within the scope of this Statement of Work, as specified in Task Orders. The Contractor shall respond to the Government within four hours of notification to determine and implement a mutually agreeable course of action. In some cases, there shall be 24-hour coverage during flight hardware and software evaluation, verification, and test. This service shall comprise of repair, modification, or replacement of components, codes, subassemblies, and assemblies. Documentation updates shall be required as a result of any change.

G. Sustaining Engineering Services

The Contractor shall provide sustaining engineering services for hardware and software within the scope of this Statement of Work, including:

1. Modifications of hardware/firmware and software, including installation of elements for improved reliability and/or performance
2. Modifications of wiring to improve circuit performance
3. Fabrication, assembly, wiring, and testing of printed circuit assemblies where necessary to update old circuitry or improve reliability
4. Engineering, fabrication, testing of assemblies or sub-assemblies to replace outdated circuitry to eliminate component or circuit failures
5. Engineering, fabrication, assembly, and testing of engineering circuits to correct problems encountered
6. Modifications of mechanical assemblies, structures, and mechanisms to correct or improve the design
7. Update of drawings, manuals, and technical data to reflect current status at the time of modifications
8. Firmware and software modifications in response to approved changes, including problem fixes.

H. Education Services

The Contractor shall provide education services, including:

1. Supporting the AETD Systems Engineering Education and Development (SEED) program and Science & Engineering Collaboration Program (SECP) as well as the HQ System Engineering Leadership Development Program (SELDLP).
2. Supporting educational outreach programs with universities and NASA headquarters.
3. Supporting MESAD and ISTD division or branch-level educational programs and training.

I. Standards and Processes

The Contractor shall provide support for engineering standards work and engineering process work, including:

1. International Standard Organization (ISO) documentation and process generation.
2. Engineering standards documentation and review.
3. Engineering process documentation.
4. Activities in support of engineering process improvement.

This work shall include providing support for systems engineering capability assessment and improvement services, Task Ordering support of the Systems Engineering Working Group (SEWG), and Systems Engineering process improvement activities.

APPLICABLE DOCUMENTS AND SPECIFICATIONS

The contractor shall adhere to all applicable portions of the following documents and/or specifications in the performance of this contract. The latest updated version shall apply:

General:

NPR 7120.5, NASA Space Flight Program and Project Management Requirements
GPR 7123.1A, Systems Engineering
NPR 8705.4, Risk Classification for NASA Payloads
GPR 8070.4B, Administration and Application of Goddard Open-Learning Design (GOLD) Rules for the Design, Development, Verification and Operation of Flight Systems
GPR 8700.6B Engineering Peer Reviews
GSFC-STD-1000F, Rules for the Design, Development, Verification, and Operation of Flight Systems
NASA/SP-2007-6105 Rev 1, NASA Systems Engineering Handbook

Launch Vehicles:

AFSPCMAN 91-710, Range Safety User Requirements Manual
NASA-STD 8719.24, NASA Expendable Launch Vehicle Payload Safety Requirements
NPR 8715.7, Expendable Launch Vehicle Payload Safety Program

Conformal Coating and Staking:

NASA-STD-8739.1, Workmanship Standard for Polymeric Application on Electronic Assemblies

Soldering – Flight, Ground Systems:

Association Connecting Electronics Industries (IPC)/Electronics Industry Alliance (EIA)
IPC-J-STD-001E, Requirements for Soldered Electrical and Electronic Assemblies

Electronic Assemblies – Ground Systems:

IPC-A-610, Acceptability of Electronic Assemblies

Crimping, Wiring, and Harnessing:

NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring

Fiber Optics:

NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation

Electro-Static Discharge (ESD) Control:

ANSI/ESD S20.20, Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
GPR 8730.6B, Electrostatic Discharge (ESD) Control

Printed Wiring Board (PWB) Design:

500-PG-8700.2.2, Electronics Design and Development Guidelines
500-PG-8700.2.4, Mechanical Design and Development Guidelines,
GSFC X-673-64-1, Engineering Drawing Standards Manual
IPC-2221, Generic Standard on Printed Board Design
IPC-2222, Sectional Design Standard for Rigid Organic Printed Boards
IPC-2223, Sectional Design Standard for Flexible Printed Boards
IPC D-275 Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies
IPC-2225 Sectional Design Standard for Organic Multichip Modules (MCM-L) and MCM-L Assemblies
GSFC-STD-6001, Ceramic Column Grid Array Design and Manufacturing Rules for Flight Hardware

PWB Manufacture:

GSFC EEE-INST-002, Instructions for EEE Parts Selection, Screening, Qualification, and Derating
IPC A-600, Acceptability of Printed Boards
IPC-6011, Generic Performance Specification for Printed Boards
IPC-6012, Qualification and Performance Specification for Rigid Printed Boards
Flight Applications – Supplemented with: GSFC/S312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
IPC-6013, Qualification and Performance Specification for Flexible Printed Boards
IPC-6015 Qualification and Performance Specification for Organic Multichip Module (MCM-L) Mounting and Interconnecting Structures
IPC-6018, Microwave End Product Board Inspection and Test

Materials Processing

NASA-STD-6016, Standard Materials and Processes Requirements for Spacecraft

Contamination

GSFC 546-WI-8072.1.56A, Contamination Control Procedure for Tape Lift Sampling of Surfaces
IEST-STD-CC1246D, Product Cleanliness Levels and Contamination Control Program
ASTM E1559-09, Standard Test Method for Contamination Outgassing Characteristics of Spacecraft Materials
GSFC 546-WI-8072.1.82A, MOLEKIT2/3 Operating Procedures
GSFC 546-WI-8072.1.80A, Measurement OF BRDF
GSFC 546-WI-8072.1.81A, Determination of Particulate Contamination Using Automated Microscope/Image Analyzer ISO 14644, Cleanrooms and Associated Controlled Environments

Mechanical Design

541-PG-8072.1.2B, GSFC Fastener Integrity Requirements
540-PG-8700.2.1B, Design of Dollies, Stands, and Spacecraft Shipping Containers
540-PG-8719.1.1A, Lift Sling Design

ASME Y14.5M-1994, Dimensioning and Tolerancing
500-PG-8700.2.5C GSFC Engineering Drawing Requirements Manual

Environmental Testing

GSFC-STD-7000 General Environmental Verification Standard (GEVS)

Outgassing

ASTM E-595-07, Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

Outgassing Data for Selecting Spacecraft Materials Online:

<http://outgassing.nasa.gov>

Section 508 EIT Standards

1194.21 Software Applications and Operating Systems

1194.22 Web-based Intranet and Internet Information and Applications

1194.24 Video and Multimedia Products

REFERENCE DOCUMENTS AND SPECIFICATIONS

The following documents and/or specifications are provided as reference material for the performance of this contract. The latest updated version shall apply:

NASA/SP-2007-6105 Rev1, NASA Systems Engineering Handbook

ACRONYMS

ACS	Attitude Control System
ADP	Automatic Data Processing
ADR	Adiabatic Demagnetization Refrigeration
AETD	Applied Engineering and Technology Directorate
ANSI	American National Standards Institute
ASAP	Advanced Sensor Analysis Program
ASIC	Application-Specific Integration Circuit
ASTM	American Society for Testing Materials
ATR	Approved Technical Representative
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CAM	Computer Aided Manufacturing
CCB	Change Control Board
CD	Compact Disk
C&DH	Communication and Data Handling
CDR	Critical Design Review
CIA	Calibration, Integration and Alignment
CM	Configuration Management
CMMI	Capability Maturity Model® Integration
CNE	Center Network Environment
COR	Contracting Officer's Representative
CVCM	Collected Volatile Condensable Materials
DM	Documentation Management
DVD	Digital Video Disk
EED	Electrical Engineering Division
EEE	Electronic, Electrical, and Electromechanical
ELV	Expendable Launch Vehicle
EMI	Electromagnetic Interference
EMC	Electromagnetic Compatibility
EP	Electrical Propulsion
ESD	Electro-Static Discharge
ETR	Eastern Test Range
ETU	Engineering Test Unit
EVA	Extra-Vehicular Activities
EWR	Eastern/Western Range
F	Fahrenheit
FEM	Finite Element Model
FEMAP	Finite Element Modeling software by Siemens PLM
FTTB	Formation Flying Test Bed
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FPGA	Field Programmable Gate Array
FRB	Failure Review Board
FTA	Fault Tree Analysis
GEVS	General Environmental Verification Standard

GFE	Government Furnished Equipment
GIDEP	Government Interagency Data Exchange Program
GN&C	Guidance Navigation and Control
GPG	Goddard Procedures and Guidelines
GPIB	General-Purpose Interface Bus
GPR	Goddard Procedural Requirements
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GUI	Graphical User Interface
ICD	Interface Control Drawing/Document
IDEAS	Software by EDS (formerly by Structural Dynamics Research Corporation)
IEST	Institute of Environmental Sciences and Technology
IMDC	Integrated Mission Design Center
ISO	International Standard Organization
ISS	International Space Station
ISTD	Instrument Systems and Technology Division
IT	Information Technology
I&T	Integration and Test
IPC	<i>formerly</i> Institute for Interconnecting and Packaging Electronic Circuits
ITS	Information Technology Security
LAN	Local Area Network
MAR	Mission Assurance Requirement
MEMS	Micro Electro-mechanical
MESA	Mission Engineering and Systems Analysis Division
MIL	Military
MIMO	Multiple Input/Multiple Output
MIP	Mandatory Inspection Point
MLI	Multi-Layer Insulation
MRB	Material Review Board
MSD	Mechanical Systems Division
N	Newton
NASA	National Aeronautics and Space Administration
NASTRAN	NASA Structural Analysis Program
NDE	Nondestructive Evaluation
NDI	Non-destructive Inspection
NHB	NASA Handbook
NPR	NASA Procedural Requirements
NSTS	National Space Transportation System
PAR	Product Assurance Requirement
PCB	Printed Circuit Board
PDR	Preliminary Design Review
PFR	Problem Failure Reporting
PG	Procedures and Guidelines
PIC	Procurement Information Circular
PR	Problem Reporting
PRA	Probability Risk Assessment
PWB	Printed Wiring Board

QCM	Quality Control Management
QMS	Quality Management System
REA	Radiation Effects Analysis
RF	Radio Frequency
R&TD	Research and Technology Development
SEMP	System Engineering Management Plans
SINDA	Systems Improved Numerical Differencing Analyzer
SISO	Single Input/Single Output
SMA	Safety and Mission Assurance
SMAP	Software Mission Assurance Plan
SSPTA	Simplified Space Payload Thermal Analyzer
STD	Standard
STOL	Spacecraft Testing and Operations Language
STOP	Structural-Thermal-Optical Performance
STS	Space Transportation System
TML	Total Mass Loss
TOMS	Task Order Management System
TRASYS	Thermal Radiation Analyzer System
TSS	Thermal Synthesizer Systems
UAV	Unmanned Aerial Vehicle
UNIX	Operating System Software
UV	Ultra Violet
WI	Work Instruction
WTR	Western Test Range
WVR	Water Vapor Regained